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TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371			U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/743738
INTERNATIONAL APPLICATION NO. PCT/DE99/01691	INTERNATIONAL FILING DATE 05/06/99	PRIORITY DATE CLAIMED 30/07/98	
TITLE OF INVENTION MECHANICAL CONNECTING ELEMENT			
APPLICANT(S) FOR DO/EO/US Hans Nusskern, Viktor Dahm			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:			
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1). 4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371 (c) (2)) <ol style="list-style-type: none"> a. <input type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input checked="" type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)). 7. <input checked="" type="checkbox"/> A copy of the International Search Report (PCT/ISA/210). 8. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3)) <ol style="list-style-type: none"> a. <input checked="" type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 9. <input checked="" type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 10. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)). 11. <input checked="" type="checkbox"/> A copy of the International Preliminary Examination Report (PCT/IPEA/409). 12. <input checked="" type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)). 			
Items 13 to 20 below concern document(s) or information included: <ol style="list-style-type: none"> 13. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 14. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 15. <input type="checkbox"/> A FIRST preliminary amendment. 16. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 17. <input type="checkbox"/> A substitute specification. 18. <input type="checkbox"/> A change of power of attorney and/or address letter. 19. <input checked="" type="checkbox"/> Certificate of Mailing by Express Mail 20. <input checked="" type="checkbox"/> Other items or information: 			
Application Data Sheet			

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14989.260

21. The following fees are submitted:

CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,000.00
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =**\$860.00**

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).

\$0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	34 - 20 =	14	x \$18.00
Independent claims	1 - 3 =	0	x \$80.00

\$252.00**\$0.00**

Multiple Dependent Claims (check if applicable).

☒**\$270.00****TOTAL OF ABOVE CALCULATIONS =****\$1,382.00**

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable).

☐**\$0.00****SUBTOTAL =****\$1,382.00**

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+

\$0.00**TOTAL NATIONAL FEE =****\$1,382.00**

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).

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NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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26,802

REGISTRATION NUMBER

1/16/01

DATE

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CERTIFICATE OF MAILING BY "EXPRESS MAIL" (37 CFR 1.10)Applicant(s): **Hans Nusskern, Viktor Dahm**

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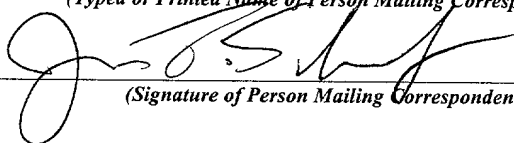
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Group Art Unit

N/A

Invention: **MECHANICAL CONNECTING ELEMENT**I hereby certify that this **Application Filing Under 35 USC 371***(Identify type of correspondence)*

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under
 37 CFR 1.10 in an envelope addressed to: The Assistant Commissioner for Patents, Washington, D.C. 20231 on

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JC07 Rec'd PCT/PTO 16 JAN 2001

PCT/DE99/01691

English translation

ERG 102/0Q/US

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Applicant: G. Rau GmbH & Co.
Pforzheim, DE

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Mechanical connecting element

- 15 The invention relates to a connecting element for me-
chanically connecting constructive elements. It comprises
an elastically deformable tensioning element which ap-
plies a holding force in its elastically deformed state,
onto at least one constructive element connected by the
20 connecting element, thus generating a nonpositive connec-
tion of at least one constructive element with the ten-
sioning element or with another constructive element. In
particular, the invention relates to the linking of lon-
gitudinal, wire-shaped constructive elements as e.g. pro-
25 files and tubes, also with small diameters in the range
of a few millimeters or less. A connection is to be un-
derstood as the joint of a tensioning element to a con-
structive element to be connected, or the connection of
two or more constructive elements to each other. In par-
30 ticular, the invention relates to the mechanical connec-
tion of constructive elements consisting of a material
which is difficult to weld or to solder, e.g. a nickel-
titanium alloy.

In many ranges of technology, there is the requirement to connect constructive elements mechanically, however, connections which allow to be detached if necessary, are desired, too. A usual method is to use an elastically deformable tensioning element which applies a holding force in its elastically deformed state, onto one constructive element to be connected, thus generating a nonpositive connection of at least one constructive element with the tensioning element or with another constructive element. Principally, there are two ways of deforming the tensioning element elastically.

The first variant is to bring the tensioning element from a relaxed initial position into a pre-tensioned position by means of an elastic deformation, where it is deformed and elastically expanded. In the pre-tensioned position, the constructive element to be connected (at least one) can be inserted into the tensioning element (or, if necessary, vice versa, the tensioning element into the constructive element). After that, the tensioning element is allowed to return to a less tensioned position, where it applies a holding force, caused by the elastic deformation, onto the connected constructive element. This holding force generates the nonpositive connection.

The second possibility is to bring the tensioning element from its relaxed initial position into a tensioned position, where the mechanical tension generated by the expansion causes the holding force. The tensioning element can be pre-tensioned in an opposite direction before the insertion of the constructive element to be connected, if necessary.

Thus, as to the state of the art, it is known to fit coil springs made of steel to the ends of Allan keys; these

coil springs are wound around the tip of the key in a way that the coil spring fixes the key in a non-positive way due to the spring load. With this, the key can be fixed to a bunch of keys by means of the coil spring. According
 5 to the first described variant, the coil spring is expanded for inserting the Allen key, and generates the holding force in a partially relaxed position. On the other hand, the coil spring can also be applied to the key by the second described variant, being contracted and
 10 decreasing the diameter, which presents similarities with crimping; this, too, generates a holding force by the winding around the key end.

{Another known example from the state of the art are
 15 shrinking joint sleeves for the butt joining of tubes, e.g. according to the literature reference Engineering Aspects of Shape Memory Alloys, Duerig, Melton, Stöckel, Wayman, Verlag Butterworth-Heinemann Ltd., 1990 or according to DE 4026644 C1. Here, a shape memory alloy in form
 20 of a sleeve, with a suppressed shape memory effect, is located around the joint and shrunk. The entire usable shrinking effect amounts to approximately three to four percent after subtracting the installation tolerance, the substrate tolerance, the substrate deformation during
 25 shrinking and the suppressed shape memory effect; this makes it necessary to comply exactly with the tolerances in order to generate a reliable joint. These shrunk joints are based on a one-way effect, this means that the joints cannot be detached any more. The effect applied
 30 for joining during the shrinking process is based on a phase transformation, during which the metallographic structure of the shrinking sleeve changes.

Taking into account this state of the art, the invention
 35 relates to the creation of a connecting element for me-

chanically connecting constructive elements, which allows bigger tolerances and dimensional deviations for the tensioning element and/or the constructive elements, but at the same time creates a high holding force. The strength
 5 of the connection and the generated holding force must be high. Furthermore, it is desirable to detach the realized connection if necessary.

The solution according to the invention, for a connecting
 10 element for mechanically connecting constructive elements, comprising an elastically deformable tensioning element which applies a holding force in its elastically deformed state, onto at least one constructive element connected by the connecting element, thus generating a
 15 nonpositive connection of at least one constructive element with the tensioning element or with another constructive element, consists of the fact that the tensioning element comprises a spring material made of a superelastic shape memory alloy, in particular a nickel-
 20 titanium alloy, which is expanded elastically (purely elastically, superelastically) in the tensioning element.

For alloys containing a similar amount of titanium and nickel atoms, particular effects can be observed. Due to
 25 these effects, such alloys are also designated shape memory alloys. These effects are based on a thermoelastic martensitic phase transformation, i.e. a temperature-dependant modification of the crystalline structure: at high temperatures, the alloy is austenitic, at low temperature, however, it is martensitic. According to
 30 T. W. Duerig and H. R. Pelton, ("TI-NI Shape Memory Alloys", in: Materials Properties Handbook: Titanium Alloys, 1994, pages 1035-1048, ASM International 1994), two characteristics have to be distinguished for shape memory
 35 alloys. Alloys with a titanium content between 49,7 to

50,7 atom% show a thermal shape memory, also designated shape memory; whereas alloys with a titanium content of 49,0 to 49,4 atom% show a mechanical shape memory, also designated superelasticity. Not only binary nickel-titanium alloys can have the stated properties. A shape memory alloy can contain ternary ingredients (e.g. iron, chrome or aluminum). The relation of nickel and titanium, as well as the existence of ternary ingredients, have big influence on the intensity of the thermal and mechanical shape memory.

In order to use the thermal shape memory for constructive elements as e.g. the shrinking sleeves described above, an alloy with adequate composition is converted diffusionlessly from the austenitic crystalline structure to the martensitic crystalline structure by cooling down. A subsequent deformation of a constructive element made of this alloy can be reversed by a thermal treatment of that constructive element (heating to a temperature above a certain conversion temperature). This recovers the initial austenitic crystalline structure and the constructive element returns to its original shape. The conversion temperature is generally understood as the temperature at which the martensite has completely converted to austenite. The conversion temperature strongly depends on the composition of the alloy and on the internal tensions of the constructive element. Constructive elements which have a thermal shape memory can perform movements and/or apply forces.

For a constructive element with austenitic crystalline structure, the mechanical shape memory effect appears when the constructive element is deformed in a certain temperature range. For this, it is energetically more favorable for the austenitic crystalline structure, to

convert to martensite in a tension-induced way, whereby elastic expansions of up to 10% can be obtained. When unloaded, the crystalline structure returns to the austenitic phase. Therefore, constructive elements made of such alloys are used for the storage of deformation energy.

Alloys showing the characteristics described above are known by the designations of Nickel-Titanium, Titanium-Nickel, Tee-nee, Memorite^R, Nitinol, Tinel^R, Flexon^R, Euroflex^R and Shape Memory Alloys. These terms do not refer to a single alloy with a certain composition, but to a family of alloys showing the described characteristics.

Due to the particular properties of nickel-titanium alloys, there is a high interest in many fields of technology, e.g. medical engineering and precision mechanics, in the application of constructive elements made of shape memory alloys, also in form of tubes, in particular with small outer diameter. In mechanics, they can e.g. be used for switching elements, setting elements or valves. In medical engineering, too, shape memory alloys are increasingly applied, as constructive elements made of such alloys are bio-compatible and fatigue-resistant, and because they show high buckling resistance in case of superelastic alloys. Examples for the application of nickel-titanium alloys in medical engineering are guidance wires for catheters, vessel supports (stents), as well as endoscopic and laparoscopic instruments for the minimal invasive diagnosis and therapy.

The special characteristic of superelastic shape memory alloys, consisting in achieving elastic expansions of up to ten percent, thus significantly higher than for spring materials made of steel or bronze, is applied in the scope of the invention, in order to use tensioning ele-

ments which are elastically expanded, made of such spring material. As the elastic expansion range is ten times higher as compared to a spring steel, the tolerances of invention-related tensioning elements can be bigger dimensioned.

The usable effect of the invention-related tensioning element is increased by the factor of three approximately, as compared to a shrinking sleeve made of a shape memory alloy as described above. During installation, such a shrinking sleeve is in martensitic state and converts to austenitic state when heated. The shrinking sleeve tries to restore the initial, smaller shape, thus generating the holding force.

The tensioning element according to the invention is in austenitic state already at the start of the installation and converts to the tension-induced, martensitic state during the elastic tensioning or expanding, respectively. Due to the geometric shape of the tensioning element, the usable effect can be increased by the factor three approximately, as compared to the known shrinking sleeve. In general, for an invention-related tensioning element, no elongation effects, i.e. shrinking effects, occur for the generation of the cohesive force, but merely bending forces or shear forces.

The following embodiments of the invention show further advantageous features and specialties; these are further described and explained with the schematic representation in the drawings, as follows.

Fig. 1 shows a tensioning element according to the invention in form of a compression spring.

Fig. 2 shows a compression spring during assembly.

- Fig. 3 shows a connecting element according to the invention with a compression spring.
- Fig. 4 shows a tensioning element according to the invention in form of a tension spring.
- 5 Fig. 5 shows a tension spring during assembly.
- Fig. 6 shows a connecting element according to the invention with a tension spring.
- Fig. 7 shows a connecting element according to the invention with a spring and a joint element.
- 10 Fig. 8 shows a tensioning element according to the invention in form of a leg spring.
- Fig. 9 shows a leg spring during assembly.
- Fig. 10 shows a first connecting element according to the invention with a leg spring.
- 15 Fig. 11 shows a second connecting element according to the invention with a leg spring.
- Fig. 12 shows a first connecting element according to the invention in form of a clamping sleeve.
- Fig. 13 shows a pre-tensioned clamping sleeve as to Fig. 12.
- 20 Fig. 14 shows a cross section of a first connecting element according to the invention with a clamping sleeve.
- Fig. 15 shows a longitudinal section as to Fig. 14.
- 25 Fig. 16 shows a first invention-related connecting element with leg spring and clamping sleeve.
- Fig. 17 shows a second connecting element according to the invention with leg spring and clamping sleeve.
- 30 Fig. 18 shows a second connecting element according to the invention in form of a clamping sleeve.
- Fig. 19 shows a pre-tensioned clamping sleeve as to Fig. 18.

Fig. 20 shows a cross section of a second connecting element according to the invention element with a clamping sleeve.

Fig. 21 shows a longitudinal section as to Fig. 20.

5 Fig. 22 shows a third connecting element according to the invention in form of a clamping sleeve,

Fig. 23 shows a pre-tensioned clamping sleeve as to Fig. 22.

10 Fig. 24 shows a cross section of a third connecting element according to the invention with a clamping sleeve,

Fig. 25 shows a longitudinal section as to Fig. 24.

Fig. 26 shows a fourth connecting element according to the invention in form of a clamping sleeve.

15 Fig. 27 shows a pre-tensioned clamping sleeve as to Fig. 27.

Fig. 28 shows a cross section of a fourth connecting element according to the invention with a clamping sleeve.

20 Fig. 29 shows a longitudinal section as to Fig. 28.

Fig. 30 shows a fifth connecting element according to the invention in form of a clamping sleeve.

Fig. 31 shows a pre-tensioned clamping sleeve as to Fig. 30.

25 Fig. 32 shows a cross section of a fifth connecting element according to the invention with a clamping sleeve.

Fig. 33 shows a longitudinal section as to Fig. 32.

30 Figures 1 - 6 show lateral views of connecting elements according to the invention, the tensioning element of which comprises a helicoidal spring 1, 4, 7, into which is inserted, in axial direction, at least one constructive element 2 to be connected. For this, the spring can
35 be elastically deformed and pre-tensioned for inserting

at least one constructive element into it, being partially relaxed for realizing the connection, or the spring will be tensioned in order to realize the connection. Furthermore it may be necessary to turn open the
 5 coil of the spring for increasing the diameter of the coil when inserting the mentioned at least one constructive element.

In figures 1 - 3, the tensioning element is a compression
 10 spring 1. In Fig. 1, it is illustrated in relaxed state. It consists of a shape memory alloy with superelastic characteristics. In order to connect two or more wire-shaped constructive elements 2, 3 at their face ends, the compression spring 1 will be compressed in axial direc-
 15 tion and pre-tensioned when inserting the constructive elements 2, 3. This increases the diameter of the spring, so the parts to be connected can be inserted as shown in Fig. 2. The constructive elements 2, 3 are pressed together at their face ends; this is not illustrated in the
 20 figures for reasons of clearness.

After that, the compression spring is partially relaxed as illustrated in Fig. 3, whereby it expands again in longitudinal direction, trying to reach its initial,
 25 smaller diameter. This is inhibited, as the diameter of the constructive elements 2, 3 to be connected is bigger than the initial internal diameter of the spring which it now aims to restore. This partial relaxation causes a contact pressure of the compression spring 1 onto the
 30 constructive elements 2, 3, with the compression spring now in tight contact to the constructive elements 2, 3 to be connected, generating the desired holding forces of the joint connection. The constructive elements 2, 3 to be connected at their front ends, are drawn with a gap in
 35 Fig. 3, for better presentability. For detaching the con-

nection, the pressure spring 1 can once again be pressed into a shape according to Fig. 2, thus enabling to pull out the constructive elements 2, 3.

5 Figures 4 - 6 show a connection of two constructive elements 2, 3, realized by a tension spring 4, shown in Fig. 4 in relaxed state, made of a superelastic shape memory material. The tension spring is preferably wound to a block, i.e. winding next to winding. For inserting the
10 two or more constructive elements 2, 3, the windings are opened a little, so that the diameter of the windings becomes a little bigger, and stretched in axial direction at the same time. The constructive elements 2, 3 will be pushed together with their face ends, not shown in Fig. 5
15 for a better presentability, and the tension spring 4 will be partially relaxed. Then, it adapts a state according to Fig. 6, where its diameter as well as its length are increased as compared to the initial state illustrated in Fig. 4, and decreased as compared with the
20 state according to Fig. 5. This generates a contact pressure onto the inserted constructive elements 2, 3, causing the desired holding forces of the joint connection.

Fig. 7 illustrates a cross section through a connecting
25 element according to the invention with a spring, which can be a compression spring 1, a tension spring 4, or a leg spring 7, described further below. Two or more constructive elements 2, 3 are inserted into the spring, with their face ends joined, being connected to each
30 other by the spring. The two constructive elements 2, 3 contact each other with their face ends in the range of the spring 1, 4, 7, or are oriented to each other with their face ends. The constructive elements 2, 3 are preferably rod-shaped or tube-shaped and preferably have a
35 circular cross section. However, other cross sections,

e.g. rectangular or square cross sections, are possible, too.

Alternatively, it is possible that the spring 1, 4, 7 is
 5 not wound around two constructive elements 2, 3 joined
 together, but around a core consisting of one piece, so
 that only one constructive element to be connected is in-
 serted into the spring. The inserted constructive element
 can then be connected to another element by means of the
 10 spring, e.g. with one leg of the spring.

Another advantageous feature shown in Fig. 7 can consist
 in the fact that the two or more constructive elements 2,
 3 are surrounded, in the range of their contact point, by
 15 a joint element, e.g. a joint tube 5 with thin walls or
 various joint shells, transferring the holding force of
 the spring to the constructive elements 2, 3 to be con-
 nected.

20 If the surfaces of the constructive elements 2, 3 to be
 connected, or those of a single-piece core, respectively,
 are very smooth, it can be advantageous to increase the
 holding forces by increasing the friction of a section 6
 of at least one constructive element to be connected and
 25 inserted into the spring, being engaged with the tension-
 ing element, i.e., the spring, by e.g. raising, structur-
 ing or coating. In special designs, it may occur that two
 or more constructive elements 2, 3 to be connected, are
 arranged parallel to each other within a section 6 of the
 30 spring.

Figures 8 - 11 show embodiments of connecting elements
 according to the invention, the tensioning element of
 which being a leg spring 7 shown relaxed in Fig. 8, with
 35 two legs 8, 9, consisting of a superelastic shape memory

alloy. It can be used in a way similar to the compression springs 1 and tension springs 4 described above, whereas the particularities further explained as to Fig. 7, e.g. one-piece cores, joint elements and friction-increasing sections are possible here, too.

According to a first variant illustrated in figures 9 and 10, the legs 8, 9 of the leg spring 7 are bent up during the insertion of at least one of the constructive elements 2, 3, in order to increase the diameter of its windings and for pre-tensioning of the leg spring 7 against the direction of winding of the leg spring 7. The legs 8, 9 of the leg spring 7 then are transposed to each other by a certain transposition angle. After inserting the constructive elements 2, 3 to be connected into the leg spring 7, the leg spring 7 is partially relaxed for realizing the connection; it adopts a state according to Fig. 10. By this, the diameter of its coils decreases and the desired holding force onto the inserted constructive elements 2, 3 is obtained.

As an alternative, it is also possible, starting from the relaxed state of the leg spring 7 according to Fig. 8, or starting from the pre-tensioned state of the leg spring 7 according to Fig. 9, to bend together in winding direction of the leg spring, exceeding the relaxed state, the legs 8, 9 of the leg spring 7, after the insertion of the constructive elements 2, 3 to be connected, for a decrease of the diameter of its windings, to obtain the connection. By this, the leg spring 7 is tensioned and decreases its pitch, which can be set forth until block formation, and decreases its diameter.

The diameter decrease is partially inhibited, however, by the inserted constructive elements 2, 3, as soon as the

inner diameter of the leg spring 7 comes in contact with the parts to be connected. This produces a contact pressure which obtains the desired holding forces of the joint connection. According as the leg spring 7 is or is not bent up in an intermediate step according to Fig. 9, constructive elements 2, 3 with a diameter bigger or smaller than the winding diameter, can be inserted into the leg spring 7.

For the variant illustrated in Fig. 11, the constructive elements 2, 3, the diameter of which is smaller than the leg spring 7, are inserted in an initial position according to figure 8, and the legs 8, 9 are bent together in winding direction of the spring. Preferably, the legs 8, 9 are bent together until they reach a parallel orientation. This makes it easier to fix the legs 8, 9 with respect to each other, thus assuring the maintenance of the spring tension.

For this, the legs 8, 9 can be located, e.g. side by side, and fixed with a section of a spring tube, pushed over the leg ends 8, 9, preferably consisting of a superelastic shape memory material, thus corresponding to a clamping sleeve 10, described hereafter. At the same time, one or more further pieces can be introduced and also joined into the other end of the sleeve, fixing the tensioned legs 8, 9 of the leg spring 7.

Figures 12 - 15 illustrate a first connecting element according to the invention which comprises a tensioning sleeve 10 made of a superelastic shape memory material as connecting element. Fig. 12 illustrates a cross section through the clamping sleeve 10. In its relaxed state, it preferably shows a circular cross section; in the pre-tensioned state according to Fig. 13, and in the par-

tially relaxed state according to Fig. 14, it presents an oval cross section.

For the insertion, in axial direction, of the constructive elements 2, 3 to be connected, into the clamping sleeve 10, it is necessary to bring the clamping sleeve 10 from the position illustrated in Fig 12, to the oval form according to figure 13, by compressing it. Hereby, the clamping sleeve 10 is elastically deformed and pre-tensioned. In this state, both constructive elements 2, 3 to be connected are inserted, according to the cross section in Fig. 14; after that, the clamping sleeve 10 is relaxed.

The unloading partially relaxes the clamping sleeve 10; it aspires to recover its initial, round state. This, however, is partially impeded, as the inserted constructive elements 2, 3 together have a dimension that is bigger than the initial inner diameter of the clamping sleeve 10. This generates a force pressing together the constructive elements 2, 3 to be connected, joining them reliably. For detaching the connection, the clamping sleeve 10 can once again be pressed into a shape according to Fig. 13, bringing it into a pre-tensioned state, enabling to pull out the constructive elements 2, 3.

As compared to a conventional spring steel or a spring bronze, which allow a maximum elastic expansion of 0.5%, the clamping sleeve 10 according to the invention, consisting of a superelastic shape memory, offers the advantage to allow up to 8% or more of elastic expansion. Thus, it is possible to allow bigger tolerances, whereas, e.g., half of the usable expansion range can be applied for the manufacturing tolerances and the other half can

be applied for the maintenance of the elastic deformation and the generation of the holding forces.

Also as compared to the known shrinking sleeves consisting of shape memory alloys, used for shrinking connections, the clamping sleeves 10 according to the invention offer essential advantages, as they allow bigger tolerances and dimensional deviations without affecting the function. For example, a pre-expanded shrinking sleeve of an inner diameter of 0.80 mm, can be shrunk to an inner diameter of 0.76 mm as a maximum. On the other hand, a round, superelastic tube section of a clamping sleeve 10 with an inner diameter of 0.80 mm can be compressed to an inner diameter of 0.47 mm without a permanent deformation of the pre-tensioned tube. The holding forces for this are generated by elastic deformations, bending forces and expansions.

In the embodiment according to the figures 12 - 14, the outer diameter of the clamping sleeve 10 in its initial state is 1.00 mm according to Fig. 12, and the inner diameter is 0.82 mm. In the pre-tensioned state according to Fig. 13, the large outer diameter is 1.62 mm, the large inner diameter is 1.44 mm, the small outer diameter is 0.64 mm and the small inner diameter is 0.46 mm. The diameter of the two constructive elements 2, 3 is 0.45 mm each, so that the clamping sleeve 10 according to Fig. 14, shows following dimensions in the partially relaxed state: large outer diameter 1.10 mm, large inner diameter 0.92 mm, small outer diameter 0.90 mm and small inner diameter 0.72 mm.

Fig. 15 illustrates a section A - A' according to Fig. 14. The section B - B' corresponds to the representation in Fig. 14. It can be seen that the constructive elements

2, 3 to be connected, are inserted into the tube-shaped clamping sleeve 10; the constructive elements are arranged parallel to each other in a section of clamping sleeve 10. As an alternative, more than two constructive elements to be connected, can be inserted into the clamping sleeve 10. Furthermore, embodiments are possible, in which two or more constructive elements 2, 3 to be connected, are inserted, which contact each other with their face ends in the clamping sleeve 10, or which are oriented with their ends facing to each other.

The respective ends of the connected constructive elements 2, 3 can be inside of the clamping sleeve 10, as shown in Fig. 15, or stick out of the clamping sleeve 10. The holding force generated by the clamping sleeve 10 is determined by the mechanical material properties, the dimensions, the geometric conditions and the surface structure. If the clamping sleeve 10 has a corresponding length, it can achieve a tensile strength of the connection which is higher than that of the connected constructive elements 2, 3.

Fig. 16 illustrates a connecting element fulfilling the function of a T-junction. A leg spring 7 is wound around a constructive element 2; the legs 8, 9 of the leg spring 7 are fixed with a clamping sleeve 10. This procedure generates a fixed connection of the leg spring 7 and the constructive element 2. A further constructive element 3 is inserted in the clamping sleeve 10, and fixed together with the legs 8, 9. It is held, together with the legs 8, 9, by the clamping sleeve 10 by means of elastic deformation forces.

In Fig. 17, a leg spring 7 is wound around a constructive element 2 and connected to it, e.g., as described in fig-

ures 10 and 11. One of the legs 8 is connected to a further constructive element 3 with a clamping sleeve 10; the other leg 9 is connected to a further constructive element 3a with a clamping sleeve 10a. By this, it is possible to generate cross junctions.

Figures 18 - 21 correspond to the figures 12 - 15 and show a second connecting element according to the invention, featuring a clamping sleeve 10 with two or more constructive elements 2, 3 to be connected, inserted; these constructive elements can contact each other with their face ends in the clamping sleeve 10, or are oriented with their ends facing to each other. In its relaxed state (Fig. 18), the clamping sleeve 10 can show a circular cross section, and in the pre-tensioned state (Fig. 19), and in the partially relaxed state (Fig. 20), an oval cross section. In this example, the cross section of the parts to be joined is oval.

Figures 22 - 25 correspond to the figures 12 - 15 and show a third connecting element according to the invention, featuring a clamping sleeve 10 with two constructive elements 2, 3 inserted; these constructive elements are oriented with their ends facing to each other. In its relaxed state (Fig. 22), the clamping sleeve 10 can show an oval cross section, in the pre-tensioned state (Fig. 23), it can show a deformed state as compared to the relaxed state, e.g. a circular or oval cross section, and in the partially relaxed state (Fig. 24), an oval cross section. In this example, the cross section of the constructive elements 2, 3 to be joined is circular.

Figures 26 - 29 correspond to the figures 12 - 15 and show a fourth connecting element according to the invention, featuring a clamping sleeve 10 with two construc-

tive elements 2, 3 to be connected, inserted; these constructive elements are arranged parallel to each other within a section of the clamping sleeve 10. In its relaxed state (Fig. 26), the clamping sleeve 10 can show a circular cross section, and in the pre-tensioned state (Fig. 27), and in the partially relaxed state (Fig. 28), an oval cross section. In this example, the cross section of the constructive elements 2, 3 to be joined is rectangular.

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Figures 30 - 33 correspond to the figures 12 - 15 and show a fifth connecting element according to the invention, featuring a clamping sleeve 10 with three constructive elements 2, 3, 3a to be connected, inserted; these constructive elements are arranged parallel to each other within a section of the clamping sleeve 10. In its relaxed state (Fig. 30), the clamping sleeve 10 can show a circular or oval cross section, in the pre-tensioned state (Fig. 31) it can show a cross section deformed on three sides in radial direction, or a cross section flattened on three sides, respectively, and in the partially relaxed state (Fig. 32), a cross section arced on three sides. In this example, the cross section of the constructive elements 2, 3, 3a to be connected is circular.

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List of reference signs

5	1	Compression spring
	2	First constructive element
	3	Second constructive element
	3a	Further constructive element
10	4	Tension spring
	5	Joint tube
	6	Section
	7	Leg spring
	8	First leg
	9	Second leg
15	10	Clamping sleeve

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July 21, 2000

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Claims

- 10 1. The invention relates to a connecting element for me-
chanically connecting constructive elements (2, 3),
comprising an elastically deformable tensioning ele-
ment which applies a holding force in its elastically
15 deformed state, onto at least one connected construc-
tive element (2), thus generating a nonpositive con-
nection of at least one constructive element (2) with
the tensioning element or with another constructive
element (3),

characterized in that

- 20 the tensioning element comprises a spring material
consisting of a superelastic shape memory alloy, in
particular a nickel-titanium alloy, elastically ex-
panded in the tensioning element.

- 25 2. Connecting element according to claim 1, **character-**
ized in that the holding force is generated by bend-
ing forces and/or shear forces originated by the ten-
sioning element during the elastic expansion of the
tensioning element.

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3. Connecting element according to claim 1 or 2, **charac-**
terized in that the tensioning element is converted,
during assembly, from the austenitic state to the

tension-induced martensitic state, by elastic tensioning or expanding, respectively.

4. Connecting element according to one of the claims 1
5 to 3, **characterized in that** the holding force is a contact pressure generated by the elastic expansion of the tensioning element, applied to at least one connected constructive element, inserted into the tensioning element.
- 10 5. Connecting element according to one of claims 1 to 4, **characterized in that** the tensioning element comprises a helicoidal spring (1, 4, 7) which is inserted, in axial direction, into at least one constructive element (2) to be connected.
- 15 6. Connecting element according to claim 5, **characterized in that** the spring (1, 4, 7) is elastically deformed and pre-tensioned for inserting at least one constructive element (2), being partially relaxed for
20 realizing the connection.
- 25 7. Connecting element according to claim 5, **characterized in that** the spring (1, 4, 7) is tensioned for generating the connection.
- 30 8. Connecting element according to claim 5 or 6, **characterized in that** the spring is a compression spring (1), which is compressed in axial direction for inserting at least one constructive element (2).
- 35 9. Connecting element according to claim 5 or 6, **characterized in that** the spring is a tension spring (4), which is stretched in axial direction for inserting at least one constructive element (2).

10. Connecting element according to claim 8 or 9, **characterized in that** during the insertion of at least one constructive element (2) the coil of the spring (1, 4) is turned open for increasing the diameter of the coil.
11. Connecting element according to one of claims 5 to 7, **characterized in that** the spring is a leg spring (7).
12. Connecting element according to claim 11, **characterized in that** the legs (8, 9) of the leg spring (7) are bent up during the insertion of at least one of the constructive elements (2) in order to increase the diameter of its windings and for pre-tensioning of the leg spring (7) against the direction of winding of the leg spring (7).
13. Connecting element according to claim 12, **characterized in that** the leg spring (7) is partially relaxed for generating the connection.
14. Connecting element according to claim 12, **characterized in that** the legs (8, 9) of the leg spring (7) are bent together in winding direction of the leg spring (7), exceeding the relaxed state, for a decrease of the diameter of its windings, to obtain the connection.
15. Connecting element according to claim 11, **characterized in that** the leg spring (7) is relaxed during the insertion of at least one of the constructive elements (2) to be connected, and that the legs (8, 9) of the leg spring (7) are bent together in the winding direction of the leg spring (7) for a decrease of

the diameter of its windings and for generating a tension in the leg spring (7), to obtain the connection.

- 5 16. Connecting element according to one of the claims 5 to 15, **characterized in that** a constructive element (2) to be connected, is inserted in the spring (1, 4, 7).
- 10 17. Connecting element according to one of the claims 5 to 15, **characterized in that** at least two constructive elements (2, 3) to be connected, are inserted in the spring (1, 4, 7).
- 15 18. Connecting element according to claim 17, **characterized in that** at least two constructive elements (2, 3) contact each other with their face ends, or are oriented with their ends facing to each other.
- 20 19. Connecting element according to claim 18, **characterized in that** connected constructive elements (2, 3) are surrounded, in the range of their contact point, by a joint element, in particular a joint tube (5) or various joint shells, transferring the holding force
25 of the spring (1, 4, 7) to the constructive elements (2, 3) to be connected.
20. Connecting element according to claim 17, **characterized in that** connected constructive elements (2, 3)
30 within the spring (1, 4, 7) are arranged parallel to each other in a section (6).
21. Connecting element according to one of claims 1 to 4, **characterized in that** the tensioning element comprises a clamping sleeve (10), into which at least
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one constructive element (2) to be connected, is inserted in axial direction, whereby the clamping sleeve (10) is elastically deformed and pre-tensioned by compression, for inserting the at least one constructive element (2), and is partially relaxed for realizing the connection.

22. Connecting element according to claim 21, **characterized in that** the clamping sleeve (10) shows a circular cross section in the relaxed state, and shows an oval cross section in the pre-tensioned and in the partially relaxed state.
23. Connecting element according to claim 21, **characterized in that** the clamping sleeve (10) shows an oval cross section in the relaxed state, and shows a deformed state as compared to the relaxed state, e.g. a circular or oval cross section, in the pre-tensioned state, and shows an oval cross section in the partially relaxed state.
24. Connecting element according to claim 21, **characterized in that** the clamping sleeve (10) shows an oval or circular cross section in the relaxed state, and shows a cross section deformed on three sides in radial direction in the pre-tensioned state, and shows a cross section arced on three sides in the partially relaxed state.
25. Connecting element according to one of the claims 21 to 24, **characterized in that** two or more constructive elements (2, 3) to be connected, are inserted in the clamping sleeve (10), being arranged parallel to each other within a section (6) of the clamping sleeve (10).

26. Connecting element according to one of the claims 21 to 25, **characterized in that** two or more constructive elements (2, 3) to be connected, are inserted in the clamping sleeve (10), which contact each other with their face ends in the clamping sleeve (10), or which are oriented with their ends facing to each other.
27. Connecting element according to claim 11 and one of the claims 21 to 26, **characterized in that** at least one of the legs (8, 9) of the leg spring (7) is inserted in the clamping sleeve (10).
28. Connecting element according to claim 27, **characterized in that** both legs (8, 9) of the leg spring (7) are inserted in the clamping sleeve (10).
29. Connecting element according to one of the claims 27 to 28, **characterized in that** another constructive element (3) to be connected, is inserted in the clamping sleeve, which is arranged, within the clamping sleeve (10), besides at least one leg (8) of the leg spring (7).
30. Connecting element according to one of the claims 1 to 29, **characterized in that** at least one constructive element to be connected is inserted in the tensioning element, and a section (6) engaged with the tensioning element, of at least one of the constructive elements (2) to be connected, is friction-increased.

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Summary

The invention relates to connecting elements for mechanically connecting constructive elements (2, 3). It is proposed to use an elastically deformable tensioning element (10), comprising a spring material consisting of a super-elastic shape memory alloy, in particular a nickel-titanium alloy, elastically expanded in the tensioning element (10).

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(Fig. 14)

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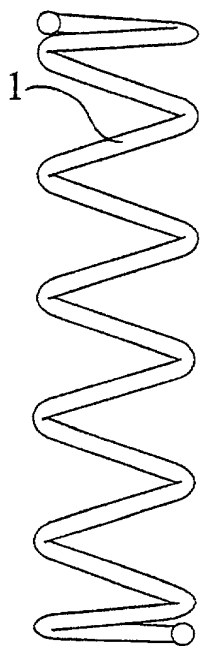


Fig. 1

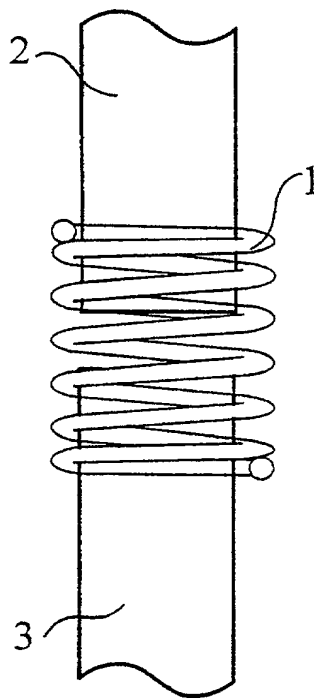


Fig. 2

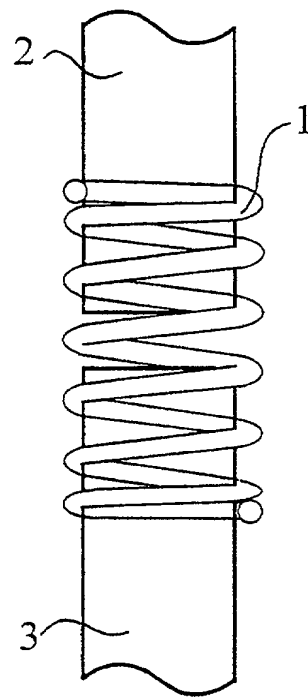


Fig. 3

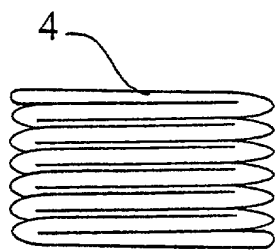


Fig. 4

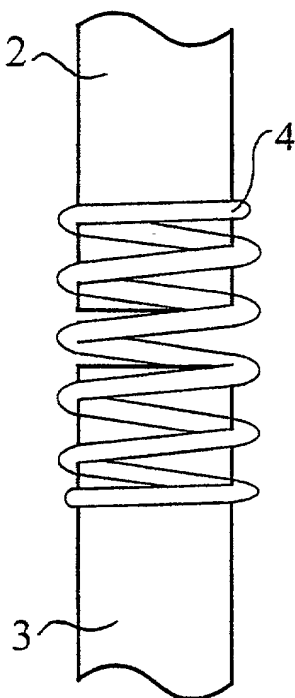


Fig. 5

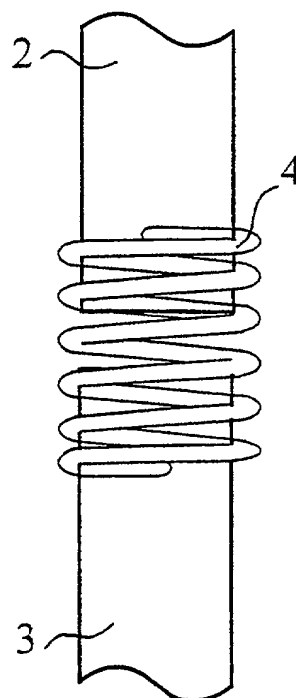


Fig. 6

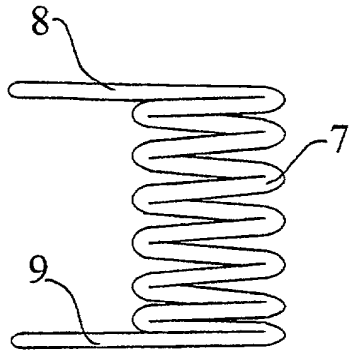


Fig. 8

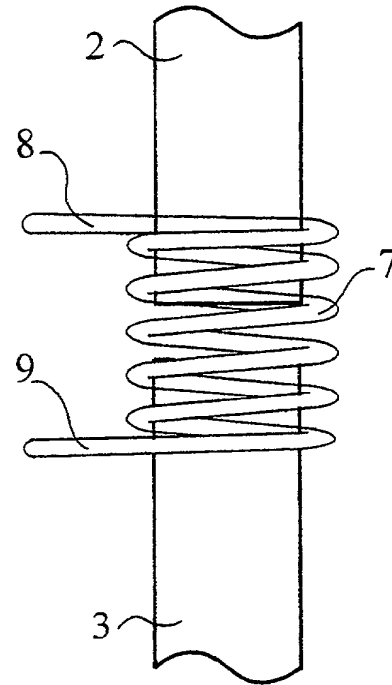


Fig. 9

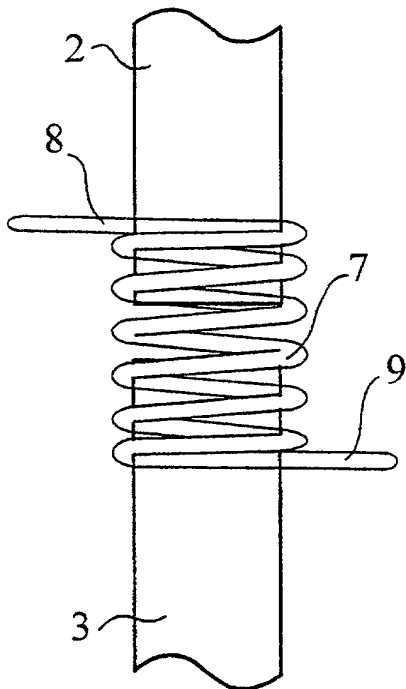


Fig. 10

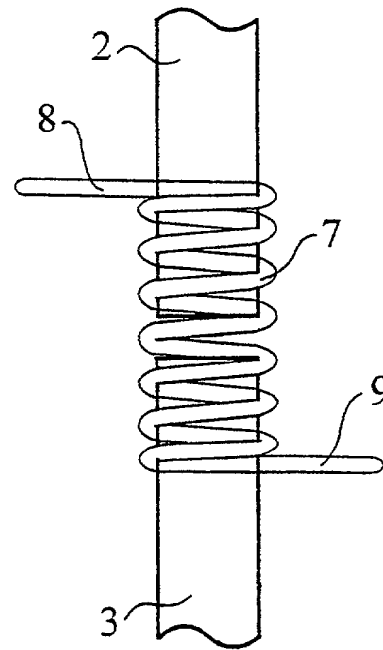


Fig. 11

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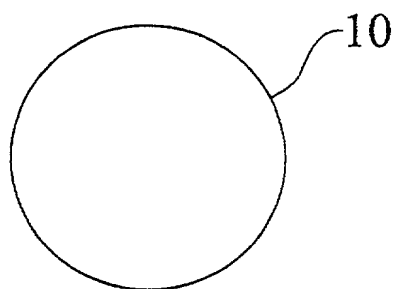


Fig. 12

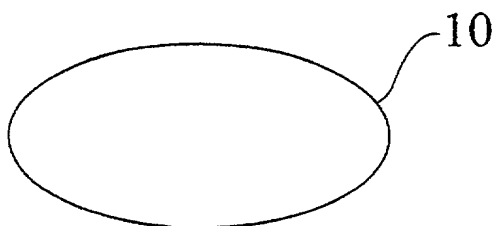


Fig. 13

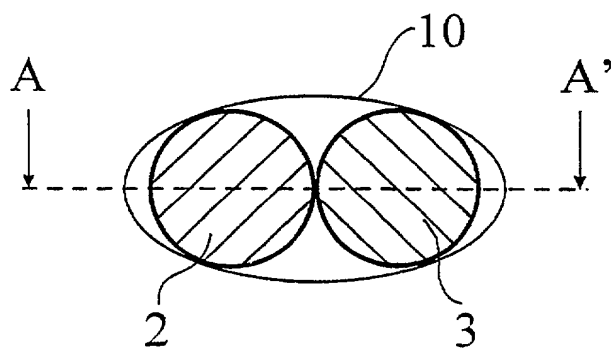


Fig. 14

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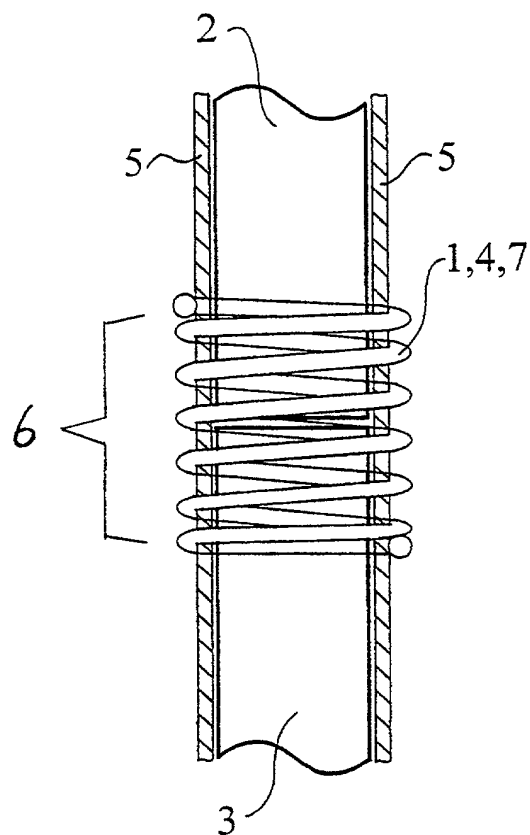


Fig. 7

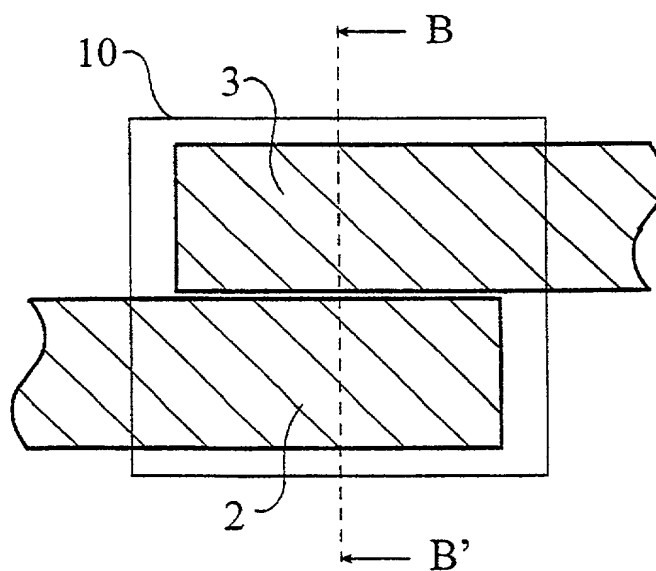


Fig. 15

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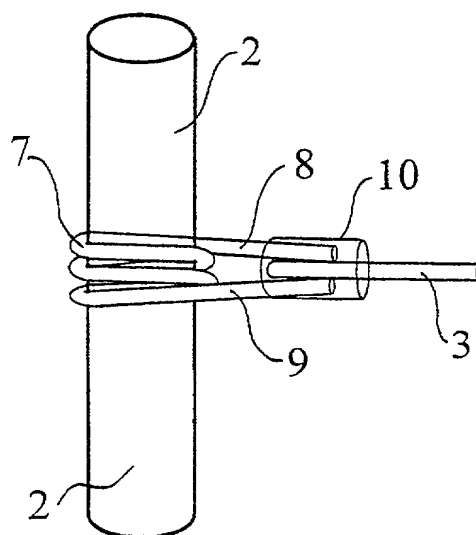


Fig. 16

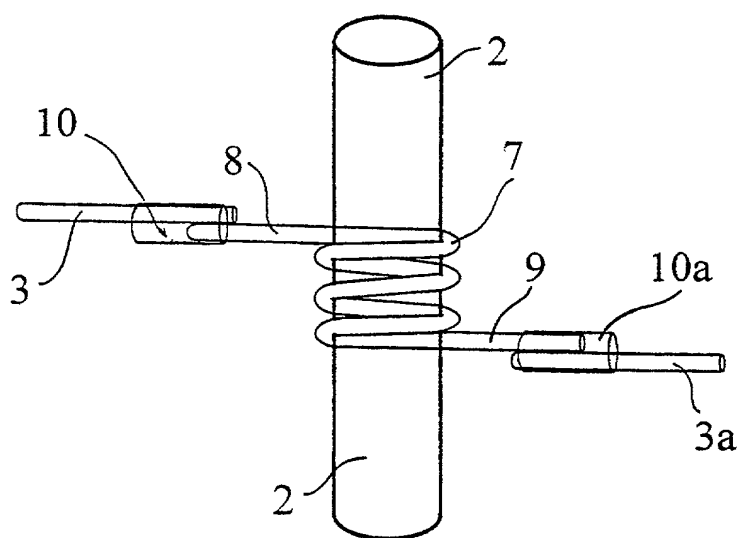


Fig. 17

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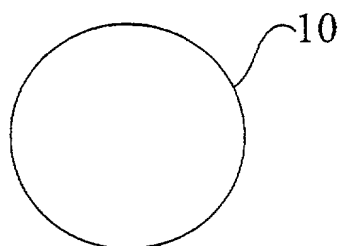


Fig. 18

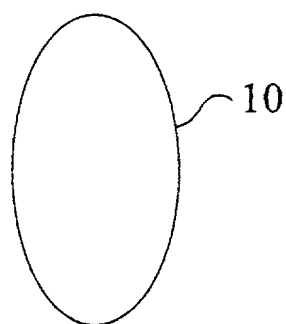


Fig. 19

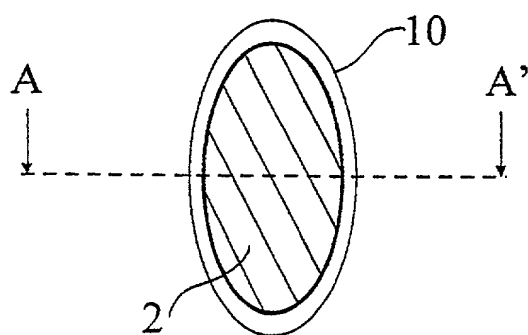


Fig. 20

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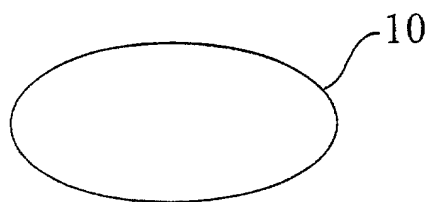


Fig. 22

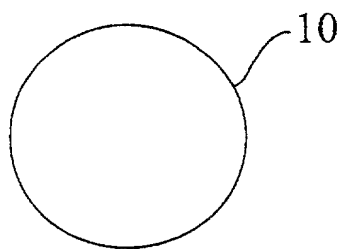


Fig. 23

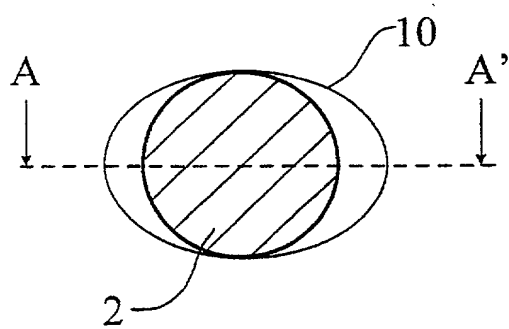


Fig. 24

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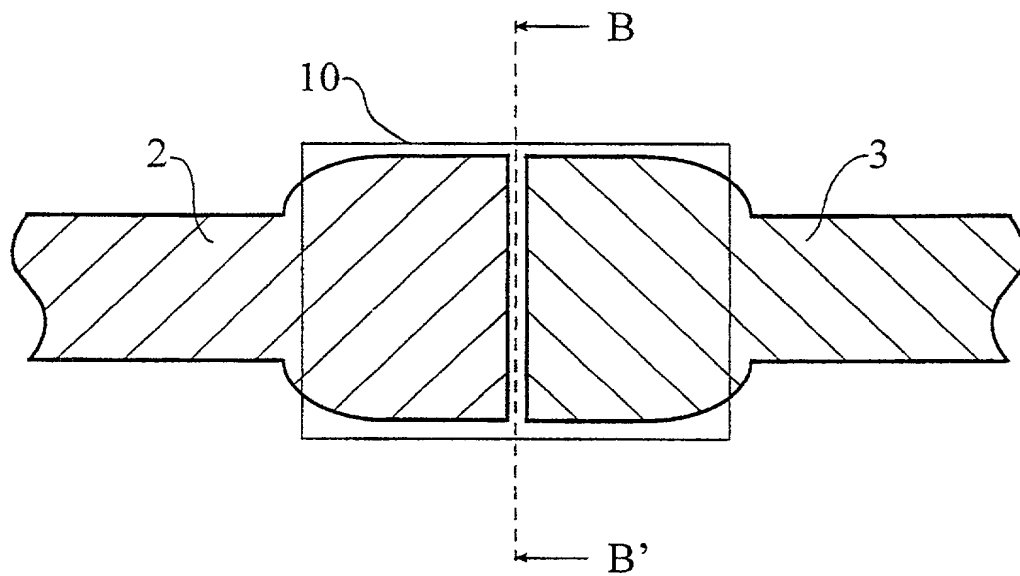


Fig. 21

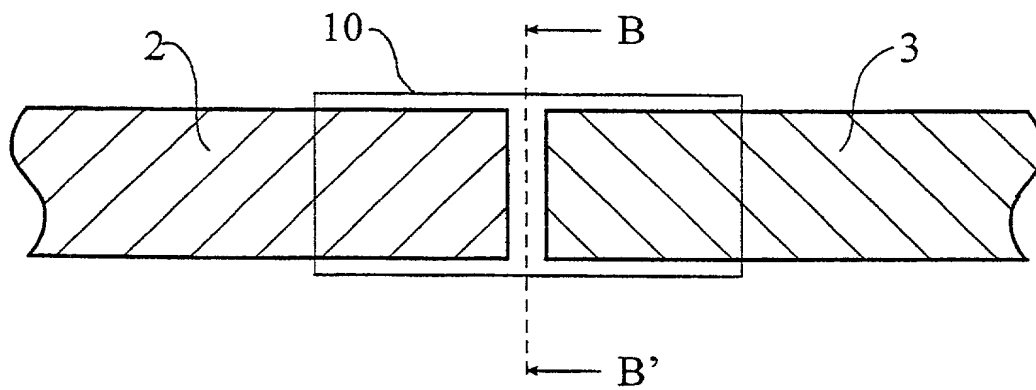


Fig. 25

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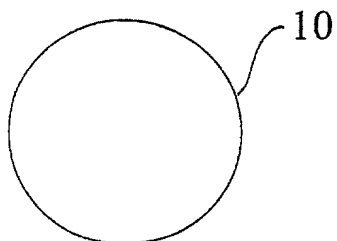


Fig. 26

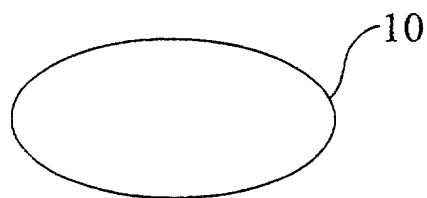


Fig. 27

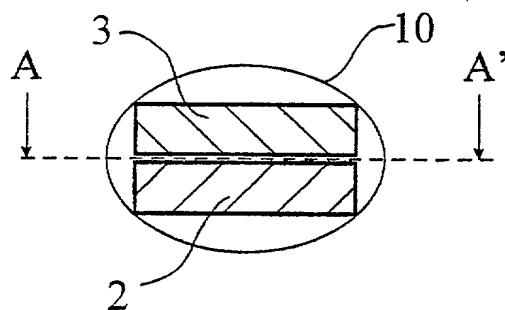


Fig. 28

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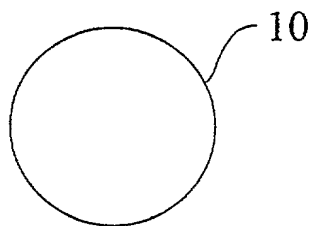


Fig. 30

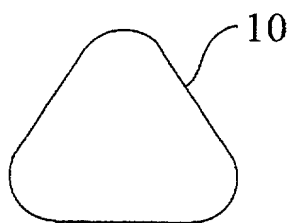


Fig. 31

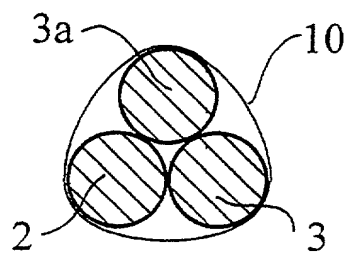


Fig. 32

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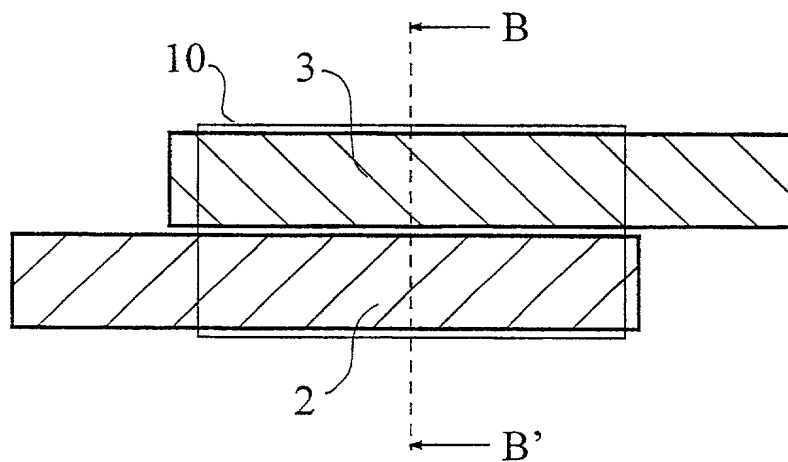


Fig. 29

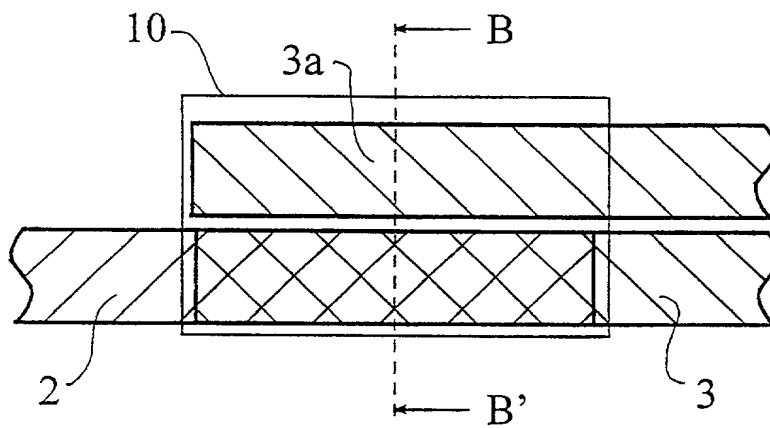


Fig. 33

Express Mail Label No. EL680595347US

Page 1 of 3

Docket No.
14989.260**Declaration and Power of Attorney For Patent Application****English Language Declaration**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MECHANICAL CONNECTING ELEMENT

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International
Application Number _____
and was amended on _____

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

198 34 305.1

Germany

July 30, 1998

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)
_____ (Application Serial No.)	_____ (Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

PCT/DE99/01691 _____ (Application Serial No.)	June 5, 1999 _____ (Filing Date)	Pending _____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.)	_____ (Filing Date)	_____ (Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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2-00

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Citizenship	German	
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2-00

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Citizenship	German	
Post Office Address	Same as above	